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STUDIES IN THE CRUCIFERAE OF WESTERN NORTH AMERICA

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SIGNIFICANT NEW TAXA of the family Cruciferae keep surfacing as a result of the search for rare and endangered species. This work, under the auspices of various federal government agencies and state natural heritage programs, is accompanied by the renewed interest of both amateurs and professionals in the native flora and fauna. In the western United States participants are getting into areas never before explored by botanists, and some of the resulting discoveries are spectacular (Rollins, 1982). Although the western United States is one of the principal centers of diversity for the Cruciferae and the area might therefore be expected to yield an occasional taxon never before seen, the number being brought to light is almost an embarrassment considering that I have been pursuing systematic studies on this family for more than 45 years.

Of even greater interest than their newness, however, is the fact that some of these new taxa form the basis for an understanding of evolutionary pathways heretofore not fully grasped. For example, the silique morphology of *Physaria obcordata* Rollins, a new species described below, helps to explain how species of *Physaria* (Nutt.) A. Gray have evolved an added mode of seed dispersal entirely different from that of their putative evolutionary progenitors in *Lesquerella* S. Watson.

It has generally been agreed (Payson, 1922; Rollins, 1939, 1950; Maguire & Holmgren, 1951; Mulligan, 1968; Rollins & Shaw, 1973) that *Physaria* is very closely related to *Lesquerella* and was probably derived from it evolutionarily. Of these two genera, *Lesquerella* contains the more primitive species; therefore, identifiable trends away from features characteristically present in that genus would represent evolutionary changes—perhaps toward superior fitness for survival.

The efficiency of seed dispersal is something that can be examined in this connection. In *Lesquerella* the valves of the siliques dehisce and fall away, leaving the seeds to fall more or less independently. Thus, the seeds are freed from the siliques to be dispersed by whatever agent is operative. In the region

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where *Lesquerella* abounds, wind and water are (aside from gravity) perhaps the most important dispersing agents for seeds of the type produced by *Lesquerella* and *Physaria*.

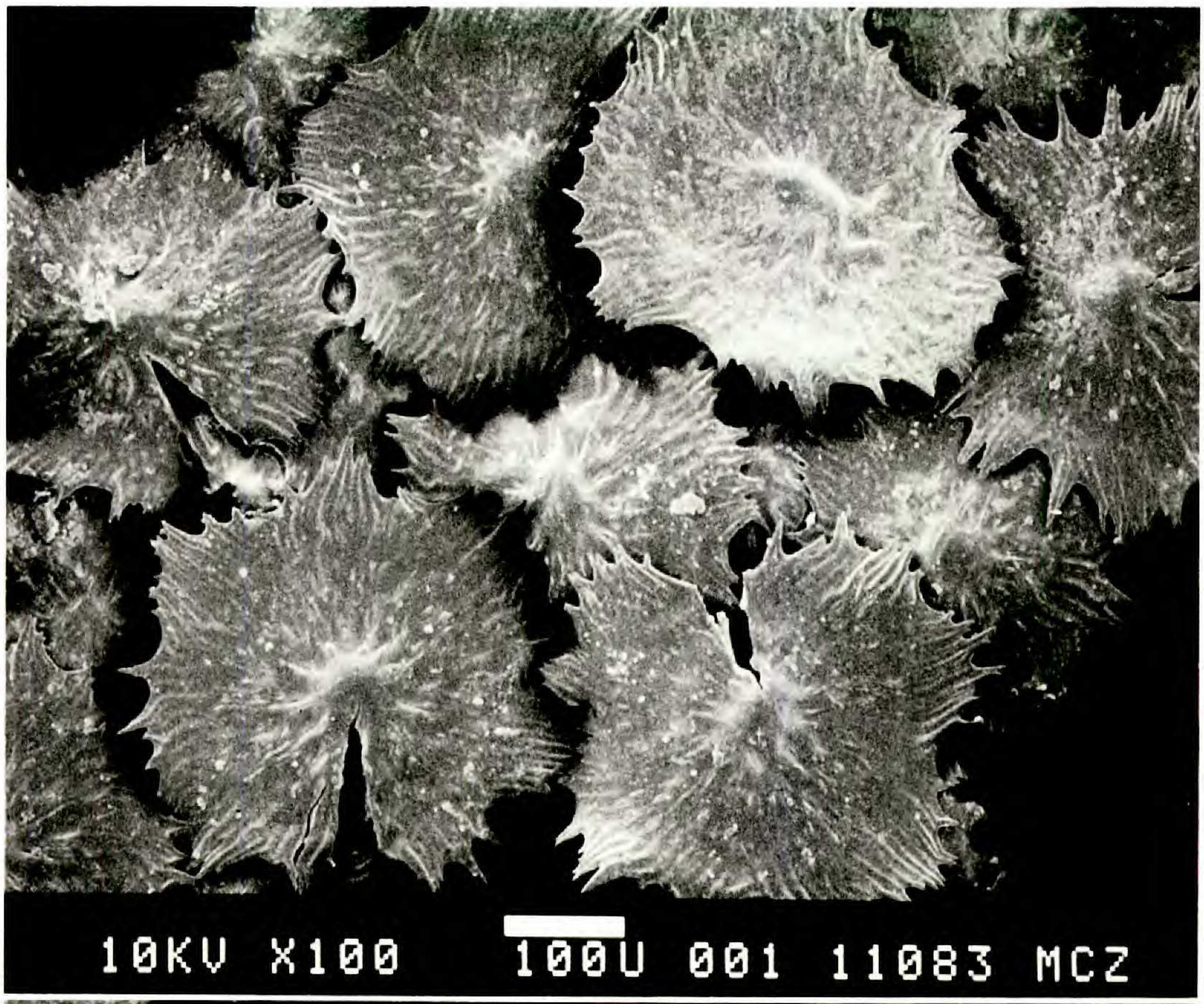
Although wind is a very important dispersing agent for many species in the more arid parts of western North America, none of the many species of *Lesquerella* in this region (Rollins & Shaw, 1973) has evolved a mechanism to take advantage of wind dispersal. The seeds are not winged in the more westerly species, although they are narrowly winged or margined in some from the more easterly range of the genus (Texas to Alabama and Tennessee). The siliques of *Lesquerella* are in no way modified for wind dispersal. In *Physaria*, however, the siliques show an evolutionary line from a situation similar to that of *Lesquerella* to one in which the silique valve has become modified so that the valve, enclosing one or more seeds, is the unit of dispersal rather than the seed itself. With narrowing of the replum and constriction of the valves, the seeds become entrapped and can go only where the valves take them. The inflated valves become highly mobile after dehiscence and are moved by even mild wind currents.

Of the several evolutionary trends recognizable in *Physaria*, two are easily associated with dispersal. The first is a trend from minimum lateral constriction of the valves at the replum with no entrapment of the seeds, as found in *P. obcordata* and *P. geyeri* (Hooker) A. Gray, to a situation of maximum lateral constriction of the valves at the replum and a complete entrapment of the seeds within, as in *P. acutifolia* Rydb., *P. chambersii* Rollins, *P. floribunda* Rydb., and several other species. In the most extreme cases the orifices of the valves are so narrow that seeds are not spilled out as the valves are tumbled along by the wind. This ensures movement of the seeds away from the parent plant—in many instances for a considerable distance. The second trend is from scarcely inflated valves (as shown by *P. geyeri*) through modestly inflated (as in *P. obcordata*) to highly inflated ones (as in *P. chambersii*, *P. lepidota* Rollins, *P. newberryi* A. Gray, and several other species). In addition, more or less indurated valves tend to be uninflated, while papery ones are highly inflated. This can be seen between and even within species: for example, some populations of *P. acutifolia* and *P. alpestris* Suksdorf have siliques with only slightly inflated, indurated valves, while others have siliques with thinner, highly inflated ones. Over most of the geographic range of the species, populations of *P. didymocarpa* (Hooker) A. Gray have siliques with heavy-walled valves, but var. *integrifolia* Rollins, which is restricted to western Wyoming and eastern Idaho, has thin, highly inflated valves. In each of these cases, the thin, inflated silique valves are better adapted for wind dispersal than the heavier-walled, less inflated ones.

The implications of the development of a wholly different dispersal mechanism in *Physaria* not only are evolutional but also involve adaptation to the environment. Advantages might accrue to *Physaria* for either competition or long-term survival. Any such advantages are in addition to the seed-dispersal features of *Lesquerella* species of the same region, since the seeds of *Physaria* and *Lesquerella* in this area are very similar.

Three observations must be considered in determining whether or not *Physaria* has effective dispersal advantages over *Lesquerella*. First, in areas where both genera occur, *Physaria* is generally by far the more aggressive colonizer. Plants of *Physaria* readily invade the talus of road-cuts and embankments and are usually more abundant than *Lesquerella* in disturbed sites of this type throughout the Rocky Mountain and Intermountain regions (Rollins, 1981). Second, there is no substantial difference in the total distribution in the region of species of the two genera. Some species of *Physaria* have a relatively wide geographic range (for example, *P. didymocarpa*, Alberta to Wyoming; *P. acutifolia*, Idaho and Wyoming to New Mexico), while others are restricted in range (e.g., *P. lepidota*, south-central Utah; *P. condensata* Rollins, southwestern Wyoming; *P. oregona* S. Watson, Snake River drainage on the border of Oregon and Idaho). Similarly, *Lesquerella* of the Cordilleran region has widespread species, such as *L. alpina* (Nutt.) S. Watson (Alberta and Saskatchewan to Colorado and Utah) and *L. kingii* S. Watson (Idaho and Utah to California), and others with a restricted distribution, such as *L. garrettii* Rydb. (Wasatch Mountains of Utah), *L. macrocarpa* A. Nelson (south-central Wyoming), and *L. cinerea* S. Watson (north-central Arizona). Third, the fact that the seeds of *Physaria* are more readily dispersed than those of *Lesquerella* may compensate to some extent for the longevity of individual plants of *Physaria*. Observations on a plant of *P. floribunda* in Colorado showed nine successive separated positions of leaf scars from basal leaves on the enlarged caudex. This plant was at least ten years old. Individuals of most species of *Physaria* show evidence of considerable age—quite in contrast to most of the perennial species of *Lesquerella*, which tend to be short lived. Having a mechanism that moves the seeds out of the competitive range of a mother plant that is going to remain in position for many years is a distinct advantage. Otherwise the seeds are dropped nearby, and unless they are washed away the resulting young seedlings would be in direct competition with the mother plant, having an ultimate deleterious effect on the reproductive capacity of the population as a whole. Both the number of viable seeds produced and where they end up with respect to the existing plants affect a given population in size and structure.

From the above field observations on *Physaria* and *Lesquerella*, it can be concluded that the development of an entirely new seed-dispersal mechanism has not provided *Physaria* species with significant increases in geographic distribution over *Lesquerella* species of the same general region. However, it has provided the basis for aggressive colonization of disturbed habitats and has probably increased the number of individuals in many species to the point where *Physaria* is one of the most frequently seen crucifers (other than weeds) along road-cuts and fills at middle and lower elevations in the mountains of the Rocky Mountain and Intermountain states. Having an added mechanism to ensure the movement of seeds away from the mother plant counteracts to some extent the disadvantages of long-lived plants in a rapid buildup of populations in favorable sites. The long-term effect should be to keep the gene pools of populations of *Physaria* well dispersed and to provide the basis for quick utilization of new environmental conditions as they arise.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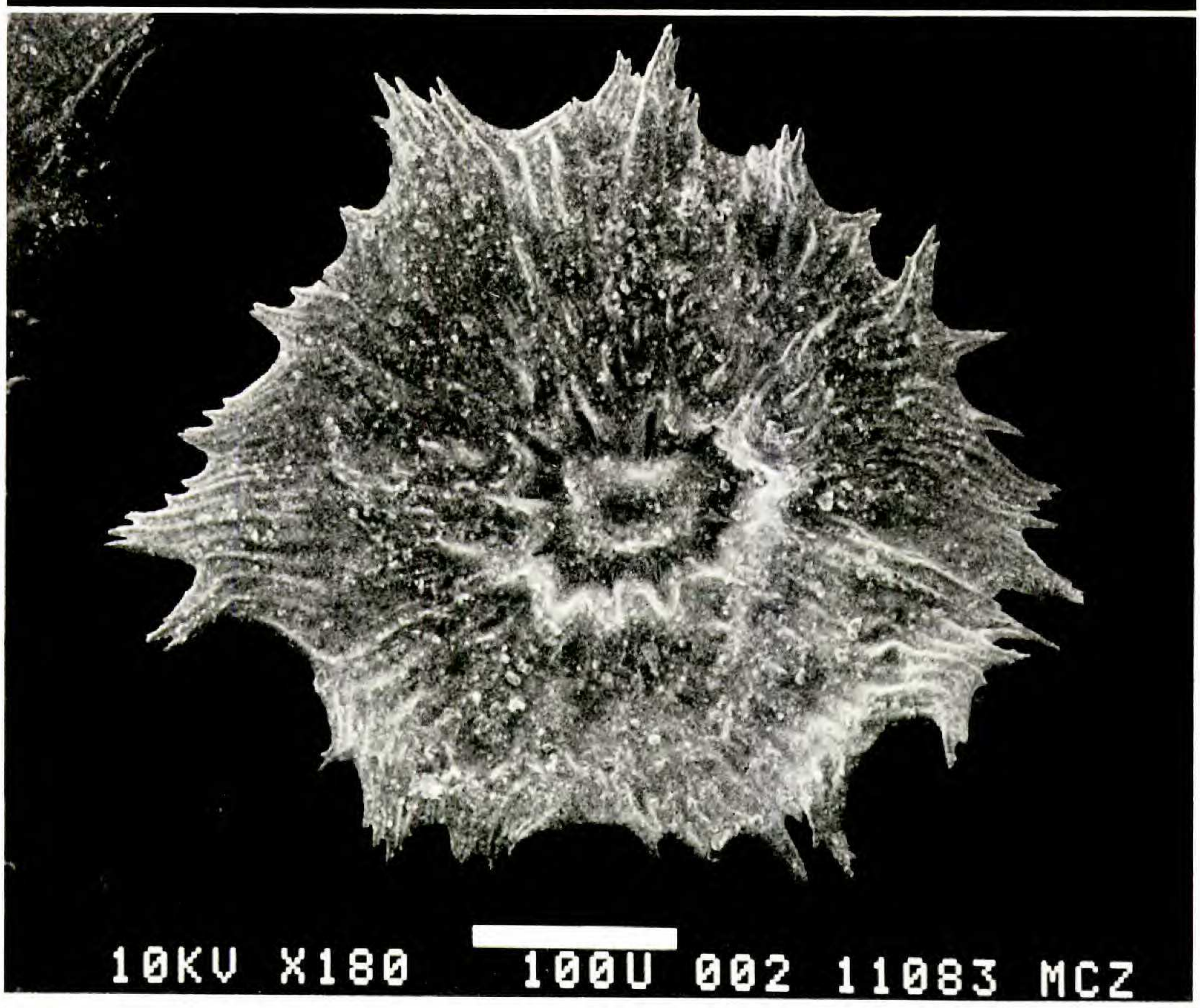
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Physaria obcordata Rollins, sp. nov. FIGURE 1.

Herba perennis; caudicibus crassis ramosis; foliis radicalibus petiolatis, late oblanceolatis, integris vel parce sinuatis, acutis, lepidotis, argenteis, 4–8 cm longis, 1–1.5 cm latis; foliis caulinis anguste lanceolatis, integris; caulibus erectis vel decumbentibus, 12–18 cm longis; pedicellis fructiferis late divaricatis vel recurvatis, 1–1.5 cm longis; siliquis didymis, parce inflatis, obcordiformibus; loculis 2-ovulatis; replo late obovato vel prope orbiculari; stylo 3–5 mm longo; seminibus immarginatis suborbicularibus; cotyledonibus accumbentibus.

TYPE. Colorado, Rio Blanco Co., T2S, R97W, S9, USGS Square S Ranch Quadrangle, ca. ¼ mi NE of junction of Hog Lot Draw and Piceance Creek, on shale of Green River Formation, 1890 m alt., 8 July 1982, *W. Baker & T. Naumann 82-277* (holotype, GH).

Perennial with deep, thickened root; thick branches of caudex invested with old overlapping leaf-bases; leaves, stems, pedicels, and siliques densely covered with minute lepidote trichomes with numerous rays fused to their tips. Basal leaves numerous, erect rather than rosulate, petiolate, 4–8 by 1–1.5 cm; blade broadly oblanceolate, acute, entire to sparingly sinuate-dentate, silvery. Fertile stems arising among basal leaves, simple, erect to decumbent, 12–18 cm long. Cauline leaves narrowly lanceolate, lower ones petiolate, upper ones cuneate at base. Flowering pedicels divaricately ascending, straight; sepals oblong, non-saccate, 4–5 by ca. 2 mm, densely pubescent; petals erect, spatulate, gradually narrowed from widest place to point of insertion, not differentiated into blade and claw, 7–9 by ca. 3 mm, yellow; filaments not expanded, the anthers sagittate, ca. 2 mm long. Infructescences elongated, occupying nearly one-half length of stems, congested; pedicels widely spreading to recurved, 1–1.5 cm long; siliques usually pendent, obcordate with deep open sinus, to nearly truncate above and with no sinus below, usually slightly inflated, the valves uneven in outline, usually with high shoulder above sinus, the replum broadly obovate to nearly orbicular, 4–5 by 3–5 mm, entire, the funiculi 2 (rarely 3 or 4) per loculus, near apex of replum, attached to septum from near middle toward base. Seeds nearly orbicular to broadly oblong, plump, wingless, 2.5–3.5 mm in diameter; radicle equaling or shorter than cotyledons; cotyledons accumbent.

SPECIMENS EXAMINED. **Colorado.** RIO BLANCO CO.: T2S, R97W, S9, USGS Square S Ranch Quadrangle, scattered on Green River Formation, ca. ¼ mi NE of junction of Hog Lot Draw and Piceance Creek, 1890 m alt., *Baker & Naumann 82-209* (CS, GH); T1N, R100W, S1, USGS Calamity Ridge Quadrangle, 0.4 mi WSW of Greasewood Mtn., 2170 m alt., *J. Walker & Riefler 82-361* (CS, GH); T1N, R100W, S1, USGS Calamity Ridge Quadrangle, 1.9 mi WNW of Caldwell Camp, 2158 m alt., *Walker & Riefler 82-363* (CS, GH); T2S, R97W, S4, USGS Square S Ranch Quadrangle, North Dudley Creek, ca. ¾ mi NE of junction of North Dudley and Piceance creeks, 1950 m alt., *Baker & Naumann 82-193* (CS, GH).

FIGURE 1. SEM photos of trichomes of **Physaria obcordata** (*Walker & Riefler 82-361*): above, overlapping layers on leaf surface (split in some trichomes an artifact produced during preparation of sample); below, single trichome showing extensive webbing between rays (point of attachment to leaf on opposite side, near center).

The epithet *obcordata* refers to the shape of the silique. The minute, scalelike trichomes and the upright basal leaves with stems arising largely within the leaf-cluster that characterize *Physaria obcordata* suggest a close relationship to *P. lepidota,* which shares these features. The latter is the only other known species of the genus that has even nearly similar trichomes. The two species resemble each other in growth habit and other characters, but their siliques are entirely different. Those of *P. lepidota* are highly inflated with deep sinuses above and below; in age, they are erect on straight or nearly straight, divaricately ascending pedicels. Those of *P. obcordata* are only slightly (if at all) inflated, with an open sinus above that varies in depth but with no sinus below; in age, they are usually pendent on recurved pedicels. Actually, the siliques of *P. obcordata* are more similar to those of *P. geyeri* (although they are less compressed than in that species) than to those of any other known species of *Physaria.* This is reflected in the shape of the replum: in *P. obcordata* it is broader, ranging from broadly obovate to nearly orbicular with a rounded apical area, while in *P. geyeri* it is narrower, ovate, and with an acute apical area. Both species usually have two ovules in each loculus, although *P. obcordata* occasionally has three or four.

The discovery of *Physaria obcordata,* which combines the silique shape and reduced ovule number characteristic of *P. geyeri* with the habit and trichome type of *P. lepidota,* strengthens the argument for keeping *P. geyeri* in *Physaria* (Rollins & Shaw, 1973) and not considering it to be a species of *Lesquerella* as was done by Mulligan (1968).

I was recently surprised to discover in a *Physaria* trichomes with numerous rays embedded in a matrix extending nearly to the ray tips (Rollins, 1981). This trichome type, while well known in the related genus *Lesquerella,* had not been seen in any species of *Physaria* until *P. lepidota* was discovered. It is quite remarkable that within two years of that discovery, another species with even more extreme trichome webbing has been found. In the trichomes of *P. obcordata,* the matrix cementing the rays together extends to the very ends of the ray tips (see FIGURE 1). These trichomes are peltate and occur in many overlapping layers, completely encrusting the surfaces of the leaves. These trichomes can be compared with those of *P. lepidota* by examining previously published SEM pictures (Rollins, 1981).

NEW TAXA OF ARABIS, DESCURAINIA, DRABA, LESQUERELLA, AND POLYCTENIUM

Arabis tiehmii Rollins, sp. nov. FIGURE 2.

Herba perennis; caudicibus crassis; foliis radicalibus erectis, spathulatis vel oblanceolatis, prope glabris, acutis, 1.5–2.5 cm longis, 4–6 mm latis; foliis caulinis 3–5, glabris, oblongis, sessilibus, 8–12 mm longis; caulibus tenuibus, glabris, 8–17 cm altis; pedicellis tenuibus, erectis vel divaricatis, rectis, 3–5 mm longis; siliquis glabris acutis 16–22 mm longis, 1.5–2 mm latis; seminibus oblongis, ca. 2 mm longis, ca. 1 mm latis; cotyledonibus accumbentibus.

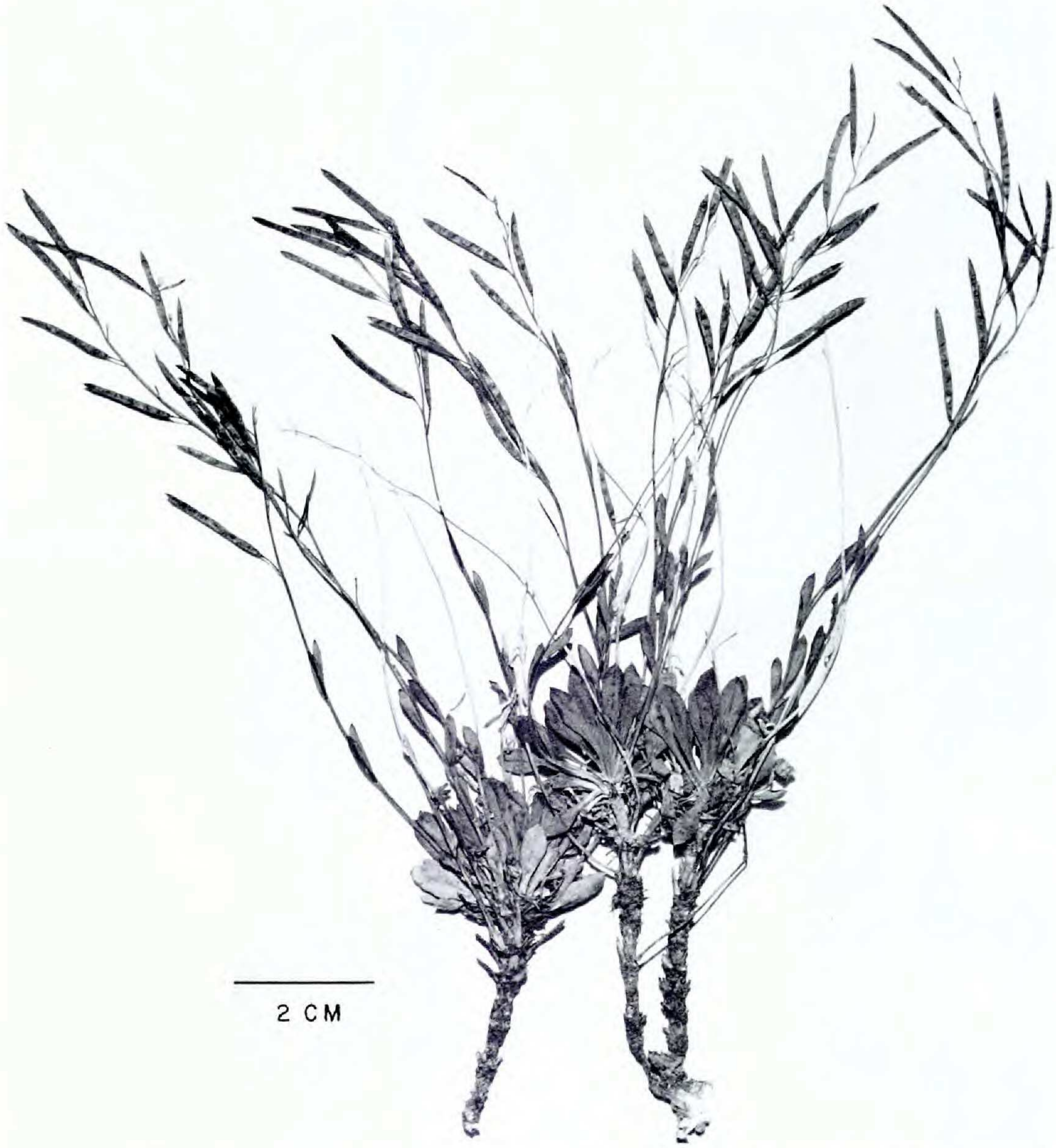

FIGURE 2. **Arabis tiehmii** (*Tiehm 7561*), showing elongated, thickened caudex with old leaf-bases.

TYPE. Nevada, Washoe Co., Sierra Nevada, Carson Range, ridge N of Mt. Rose, ¾ air mi NNW of peak, near rock outcrops on decomposed granite, 19 Aug. 1982, *A. Tiehm 7561* (holotype, GH; isotypes to be distributed).

Perennial; caudex simple or closely branched, thickened with old leaf-bases. Basal leaves tufted, erect, petiolate, 1.5–2.5 cm by 4–6 mm; blade spatulate to oblanceolate, acute and often apiculate with large simple trichome, entire, grayish green, 1-nerved from base to apex, glabrous except for marginal forked or simple trichomes on petiole margins. Cauline leaves 3 to 5, sessile, oblong, 8–12 mm long, acute, the lower ones cuneate at base, glabrous or with occasional trichomes along margin toward base, the upper ones cuneate at base or sometimes with minute auricles. Stems slender, erect to somewhat decumbent, often flexuose, 8–17 cm long, glabrous. Fruiting pedicels straight, divaricately ascending to erect, slender, 3–5 mm long, glabrous; siliques erect to slightly divaricate, flattened parallel to septum, 16–22 by 1.5–2 mm, acute, glabrous, 1-nerved below; style barely evident to less than 0.5 mm long. Seeds oblong, plump, wingless on sides but with abbreviated wing distally, ca. 2 by 1 mm; cotyledons accumbent.

In growth habit, *Arabis tiehmii* is more similar to *A. davidsonii* E. Greene than it is to any other species of *Arabis* L. The caudex is similarly thickened with old leaf-bases but is not nearly as heavy as in that species (see FIGURE 2). In such characters as the tufted basal leaves, thickened caudices, flexuose stems, and ascending siliques, *A. tiehmii* is much like *Smelowskia holmgrenii* Rollins. This resemblance prompted me to examine *S. holmgrenii* again, with the thought that it might be better placed in *Arabis* than in *Smelowskia* C. A. Meyer. The nearly terete siliques, incumbent cotyledons, and unguiculate petals, however, preclude it from the genus *Arabis*. Since these are features of *Smelowskia*, it seems best to leave *S. holmgrenii* in *Smelowskia* even though it is clearly not closely related to other known species of the genus.

In a comparison of *Arabis tiehmii* and *A. davidsonii*, differences in the length of the siliques, the length of the basal leaves, and the nature of the seeds stand out. Both the siliques and the basal leaves of *A. davidsonii* are more than twice as long as those of *A. tiehmii*. Also, the petiole of the basal leaves of *A. davidsonii* is long, while that of *A. tiehmii* is scarcely defined, with the blades merely tapering to the point of insertion. The seeds of *A. tiehmii* are narrowly oblong, with an abbreviated thickish wing only at the distal end; those of *A. davidsonii* are broadly oblong to orbicular and narrowly winged all around.

Arabis davidsonii was at one time confused with *A. lyallii* S. Watson and was even made a variety of it by Smiley (1921). However, neither *A. davidsonii* nor *A. tiehmii* is considered to be closely related to *A. lyallii*. Now that there are two known species having much-thickened caudices with numerous leaf-bases (see FIGURE 2) (vs. the relatively slender, nearly naked caudex branches of *A. lyallii*), it is easy to see the evolutionary trend that resulted in these distinctive structures. With *A. tiehmii* as a near relative, *A. davidsonii* is no longer a somewhat anomalous species in the genus *Arabis*.

J. W. Congdon C10 (GH) is a fragmentary specimen, consisting of one fertile stem, a separate infructescence, and a few basal leaves, which I previously referred doubtfully to *Arabis davidsonii*. It was collected at Mt. Warren Pass, Mono Co., California, on 21 August 1894. The siliques are short like those of *A. tiehmii*, and the seeds are oblong with more of a wing. I believe this specimen is closer to *A. tiehmii* than to *A. davidsonii*, but there is still room for doubt because of the inadequacy of the material.

Arabis rigidissima Rollins var. **demota** Rollins, var. nov.

Herba perennis; siliquis valde 1-nervatis, obtusis, 4–6 cm longis, ca. 3 mm latis; seminibus late oblongis vel prope orbicularibus, alatis.

TYPE. Nevada, Washoe Co., Sierra Nevada, Carson Range, Galena Creek, T17W, R19E, S17, 1.5 air mi ESE of Mt. Rose peak, 7900 ft alt., rocky areas at the edge of aspen groves, 26 Aug. 1982, *A. Tiehm 7572* (holotype, GH; isotypes to be distributed).

Stems one or few from branched or simple, ligneous or subligneous base, usually branched, stiff, with branches rigidly ascending. Leaves narrowly petiolate; blade oblanceolate, pubescent with 3 or 4 branched dendritic trichomes, tufted. Pedicels and siliques divaricately ascending, glabrous; siliques few, remote, straight to slightly curved, 4–6 cm by ca. 3 mm, obtuse at apex, the valves veiny, strongly 1-nerved nearly to apex, margins slightly uneven, the style absent or very short. Seeds in single row, flattened, winged, broadly oblong to nearly orbicular, 2.5–3 mm long or in diameter, wing ca. 0.5 mm wide; cotyledons accumbent.

True *Arabis rigidissima* has only rarely been collected, and to my knowledge it is restricted to Trinity and Humboldt counties in California, 200 or more miles northwest of the site where var. *demota* was found. The differences between var. *rigidissima* and var. *demota* are minor but consistent and show that the populations have diverged evolutionarily enough to merit nomenclatural recognition. In var. *rigidissima* there is a definite style present and the siliques are acuminate toward the apex, while in var. *demota* there is no style or only the barest suggestion of one and the silique apex is obtuse or at most acute. In var. *demota* the valves are prominently veined and a strong nerve beginning at the base reaches to near the tip, while in var. *rigidissima* the valves hardly show any veininess and the much-less-distinct nerve reaches only just above the middle. The seeds of var. *rigidissima* are more nearly orbicular, and the winging surrounds the entire seed; in var. *demota* the seeds are usually broadly oblong with the winging only at the distal position and along one side.

Descurainia torulosa Rollins, sp. nov.

Herba multicaulis, humifusis; caulibus tenuibus, procumbentibus, dense pubescentibus, 6–10(–13) cm longis; foliis radicalibus petiolatis, lobatis, 2–3 cm longis; foliis caulinis paucis reductis; floribus minutis; pedicellis fructiferis appressis, erectis, 1.5–2.5 mm longis; siliquis linearibus, teretibus, dense pubescentibus, erectis, torulosis, 8–12(–15) mm longis, ca. 1 mm latis; stylis tenuibus, ca. 0.2 mm longis; seminibus anguste oblongis, exalatis, ca. 1.3 mm longis, ca. 0.5 mm latis; cotyledonibus incumbentibus.

TYPE. Wyoming, Fremont Co., Wind River Range, near Brooks Lake, rocky slopes at the base of cliffs 2 mi NW of the lake, 10,000 ft alt., 8 July 1966, *R. W. Scott 761* (holotype, GH).

Biennial or possibly perennial with well-developed taproot and unbranched crown; pubescent throughout with dendritic, few- to many-branched trichomes; stems several to numerous, procumbent, arising from dense cluster of crown leaves, simple or branched, 6–10(–13) cm long. Crown leaves with petiole short; blade pinnately lobed, 2–3 cm long, primary lobes simple or with 1 or 2 subsidiary lobes. Cauline leaves few, similar to crown leaves. Flowers minute; sepals oblong, nonsaccate, slightly more than 1 mm long, with hyaline margin all around, pubescent; petals spatulate, ca. 1.5 mm long, whitish. Fruiting pedicels erect, appressed to rachis, 1.5–2.5 mm long; siliques erect and appressed to rachis, curved outward to nearly straight, terete, linear, torulose, tapered below and toward apex, 8–12(–15) mm long, slightly more than 1 mm in diameter, the style slender, ca. 0.2 mm long, smaller in diameter than stigmatic area, usually pubescent. Seeds in single row, narrowly oblong, plump, ca. 1.3 mm long, wingless, ca. 0.5 mm in diameter, dark brown; radicle slightly longer than cotyledons; cotyledons incumbent.

As Detling (1939) pointed out, there are two principal growth types found in North American *Descurainia* Webb & Berthelot: one in which the single stem branches only well above the middle, resulting in a wandlike appearance; the other with branching beginning near the base of the single stem and with the numerous erect branches nearly equal to the leader, giving a bushlike aspect to the plants. A third growth type, found in a number of South American species, is characterized by several to many more or less equal stems arising from the crown of a taproot. The stems are erect in some of these species and procumbent in others. Several of the South American species are definitely perennial, whereas all heretofore-known North American species are annuals or biennials. In habit, *Descurainia torulosa*, unlike any known North American species, shares the characteristics of those South American species with procumbent stems. This species is probably perennial rather than biennial: the taproot with its crown is well developed, and the available specimens look as though they could be perennial, but one cannot be sure from the specimens alone. In addition to its distinctive branching habit, *D. torulosa* grows so low that it does not resemble any other North American species. Also, the closely appressed but flaring torulose siliques and the extremely short pedicels characteristic of *D. torulosa* are not matched in material of other species.

Draba hitchcockii Rollins, sp. nov.

Herba perennis, caespitosa; caudicibus ramosis; caulibus scapiformibus, erectis, hirsutis, (2–)3–7(–9) cm altis; foliis rosulatis, spathulatis vel oblongis, ciliatis, (3–)4–7(–10) mm longis, (1–)1.5–2 mm latis; sepalis late oblongis, hirsutis, ca. 3 mm longis; petalis late obovatis, albis, 5–6 mm longis, ca. 4 mm latis; pedicellis rectis, hirsutis, adscendentibus, (4–)6–10(–12) mm longis; siliquis erectis, ellipticis vel late oblongis, pubescentibus (4–)5–7(–8) mm longis, (3–)3.5–4.5(–5) mm latis; stylis 1.5–2 mm longis; seminibus oblongis, ca. 1.8 mm longis; cotyledonibus accumbentibus.

TYPE. Idaho, Butte Co., S Lost River Range, T7N, R26E, S17, N side of Elbow Canyon, 23 May 1982, *A. F. Cholewa 851* (holotype, GH; isotypes, ID, NY, and others to be distributed).

Perennial; caespitose; caudex loosely branched but forming clusters up to 1 dm in diameter; branches covered with remnants of old leaves and leaf-bases, terminating in dense, recent leaf-clusters. Leaves nonpetiolate, spatulate to oblong, (3–)4–7(–10) by (1–)1.5–2 mm, obtuse, 1-nerved, ciliate on margins and upper surface with large, simple (rarely forked) trichomes, marginal trichomes often as long as leaf width, lower surface with coarse, forked to 4-branched trichomes. Scapes slender, erect or outer slightly decumbent at base, (2–)3–7(–9) cm tall, leafless, hirsute with mixture of long, simple or forked trichomes and shorter, many-branched ones; sepals broadly oblong, ca. 3 mm long, hirsute with simple or forked trichomes; petals broadly obovate, 5–6 by ca. 4 mm, pure white, blade sharply constricted to narrow claw; stamens subequal, filaments slightly dilated at base. Infructescences racemose, subcorymbose to more elongated; pedicels straight, ascending to divaricately ascending, (4–)6–10(–12) mm long, hirsute; siliques erect, elliptic to broadly oblong or nearly ovate, (4–)5–7(–8) mm by (3–)3.5–4.5(–5) mm, densely pubescent with simple or forked trichomes, the styles 1.5–2 mm long, the ovules 4 to 6 in each loculus, the funiculi less than 0.5 mm long. Seeds oblong, plump, wingless, ca. 1.8 mm long; cotyledons accumbent.

REPRESENTATIVE SPECIMENS. **Idaho.** BUTTE CO. Lost River Range: Anderson Canyon ca. 11 mi N of Arco, *S. & P. Brunsfeld 859* (GH[1]); Arco Hills area, *Reese 138, 147, 148* (GH); Elbow Canyon, *Henderson 4959* (GH); Elbow Canyon ca. 12 mi E of Mackay, *S. & P. Brunsfeld 810* (GH, NY); Cedarville Canyon, north fork, *S. & P. Brunsfeld 1102* (GH); E slope just above bottom of Jaggles Canyon, ca. 1¼ mi above entrance, *Henderson 4993* (GH); Maddock Canyon, *S. & P. Brunsfeld 821* (GH, NY), *Henderson 4979* (GH); N of Sands Canyon, *B. Anderson 29* (GH). CUSTER CO.: Lost River Range, Waddoup's Canyon, *Reese 172* (GH).

This species was named for C. L. Hitchcock, monographer of western North American *Draba* and long-time student of the flora of the Pacific Northwest.

Although *Draba hitchcockii* has white flowers, it is undoubtedly most closely related to the yellow-flowered *D. paysonii* Macbr. var. *paysonii*, which occurs in Montana and Wyoming. It also differs from that species in having longer styles, more uniformly large simple trichomes on the leaf margins and the upper leaf-surfaces, and usually longer, more slender scapes. *Draba hitchcockii* differs even more from *D. paysonii* var. *treleasii* (Schulz) C. L. Hitchc. The latter is more widespread than var. *paysonii* and occurs in the general area of Idaho where *D. hitchcockii* is found, but usually at higher elevations. Although flower color is of little or no taxonomic significance in many genera of the Cruciferae, it is an important taxonomic character in *Draba* L. When correlated with other features, it can be utilized to distinguish taxa at the specific and infraspecific levels.

The fruits of *Draba hitchcockii* and *D. paysonii* var. *paysonii* are similar in size and in the pubescence on the valve surfaces, with the trichomes either simple (especially on the silique margins) or a combination of simple and forked. In some plants of *D. hitchcockii*, only simple trichomes are found on

[1]Most, if not all, of the collections cited are probably also represented at the University of Idaho Herbarium (ID), but this has not been verified.

the entire silique. The shape of the siliques is different in the two taxa: in *D. hitchcockii* they are usually elliptic (rarely narrowly elliptic or nearly broadly ovate); in var. *paysonii* they are always broadly ovate. I have not seen any material of var. *paysonii* with anything other than a short subcorymbose infructescence, whereas in *D. hitchcockii* the infructescence is almost always racemose and is often somewhat elongated. The short stout scape and strongly condensed habit in var. *paysonii* contrast with the slender elongated scapes and the loose habit in *D. hitchcockii*.

I am indebted to Dr. Douglass Henderson, of the University of Idaho, for the following information on the plant associates and habitat of *Draba hitchcockii*. All populations are on thin soil in rocky limestone areas that range from steep to gently sloping. Accompanying species include *Leucopoa kingii* (S. Watson) W. A. Weber, *Agropyron spicatum* (Pursh) Scribner & Sm., *Cercocarpus ledifolius* Nutt. var. *intercedens* C. Schneider, *Pseudotsuga menziesii* (Mirbel) Franco, *Artemisia tridentata* Nutt., *A. arbuscula* Nutt. var. *nova* (A. Nelson) Cronq., *Phlox hoodii* Richardson, *Draba oreibata* Macbr. & Payson, and *D. densifolia* Nutt. *Cercocarpus* and *Artemisia* are the most important woody genera. Although *Draba hitchcockii* occurs at elevations from 5500 to ca. 7200 ft, most populations grow between 6000 and 6900 ft.

Draba pennellii Rollins, sp. nov.

Herba perennis, caudicibus ramosis; foliis radicalibus, pubescentibus, oblongis, acutis, 5–8 mm longis, ca. 2 mm latis; foliis caulinis 2–5, sessilibus, pubescentibus; caulibus tenuis, erectis, pubescentibus, 4–7 cm altis; pedicellis rectis, divaricatis, pubescentibus, 5–8 mm longis; sepalis oblongis, pilosis; petalis albis, obovatis, 4.5–6 mm longis; siliquis anguste ovatis, pubescentibus, ca. 5 mm longis; stylis ca. 2 mm longis; seminibus ignotis.

TYPE. Nevada, White Pine Co., Shell Creek Range, at head of South Fork of Berry Creek, on rock ledges, 10,000 to 10,500 ft alt., 13 July 1938, *F. W. Pennell & R. L. Shaeffer, Jr. 22977* (holotype, GH).

Perennial with loosely branching caudex; caudex branches elongated, partially covered with old leaves and leaf-bases, both sterile and fertile branches present in each clump; leaf-clusters elongated. Leaves nonpetiolate, oblong, 5–8 by ca. 2 mm, acute, entire, 1-nerved, densely covered with stalked, 4- or 5-branched, coarse trichomes, upper surface sometimes nearly glabrous. Flowering stems slender, simple, erect, 4–7 cm tall, densely pubescent with spreading dendritic, forked, or occasionally simple trichomes, simple trichomes increasing in frequency toward inflorescence; pedicels divaricately ascending, straight, densely pubescent with coarse, mostly dendritic and forked but occasionally simple trichomes; sepals oblong, ca. 3 by ca. 1.2 mm, greenish then turning purplish and with hyaline margin in age, sparsely covered on exterior with coarse, simple or forked trichomes; petals obovate, 4.5–6 by 3–4 mm, abruptly narrowed to short claw less than 1 mm long, truncate to shallowly retuse, white; stamens subequal, filaments dilated toward base. Siliques flattened, ovate to nearly oval, sometimes slightly asymmetric, ca. 5 by ca. 3 mm, moderately pubescent with minute forked (or simple) trichomes; styles ca. 2 mm long. Mature seeds not available.

SPECIMENS EXAMINED. **Nevada.** WHITE PINE CO.: 20 mi N of Ely, North Shell Peak, 11,800 ft alt., *Lavin 4209* (GH); Shell Creek Range, Steptoe Creek road, 9.3 mi E of U. S. Highway 93, *H. K. Sharsmith 4823* (GH).

Because cauline leaves are present on the flowering stems of both species, it is tempting to suggest that *Draba arida* C. L. Hitchc. is the closest known relative of *D. pennellii.* However, *D. arida* has rosulate basal leaves, closely branched or unbranched caudices, and only one or a few flowering stems per plant. Plants of *D. pennellii* are entirely different, consisting of numerous elongated caudex branches and basal leaves that are in elongated tufts. The number of flowering stems per plant ranges from several to many, but it is difficult to assess this feature accurately from specimens alone because the plants are tufted in cracks of rocks, making collection of a complete plant difficult. Collectors usually break off individual caudex branches. The habit of growth is much like that of *D. sphaeroides* Payson, and I am inclined to associate *D. pennellii* with that species. In both species there is stem elongation, forming well-defined internodes both between individual leaves and between tufts of leaves. Often new branches arise in the axils of individual leaves, and either these terminate in a cluster of sterile leaves, or a fertile branch arises at the terminal end of the cluster, forming an inflorescence toward its apex. The flowers of both *D. sphaeroides* and *D. arida* are yellow, while those of *D. pennellii* are pure white. The trichomes of all three species are fairly similar and cannot be relied upon as identifying characters. In *D. pennellii* the petal is distinctively shaped, with the broad, full blade narrowing abruptly to a very short claw. Neither in *D. sphaeroides* nor in *D. arida* is there a sharp differentiation into blade and claw: the blade narrows very gradually from the widest point at the apex to the point of insertion.

As compared to *Draba sphaeroides, D. pennellii* has fertile stems with 2 to 5 leaves (vs. a leafless scape); white, obovate petals that are sharply differentiated into blade and claw (vs. yellow, spatulate, and gradually tapered from blade to claw); and dense pubescence extending up the fertile stems to include the pedicels of the infructescence (vs. the upper portion of the fertile stems and pedicels glabrous). In both species the siliques are either pubescent with minute forked or simple trichomes, or glabrous.

Lesquerella goodrichii Rollins, sp. nov. FIGURE 3.

Herba perennis; caudicibus ramosis densis; caulibus decumbentibus vel erectis, tenuibus, 8–14 cm longis; foliis radicalibus erectis, dense pubescentibus, argenteis, petiolatis, (1.5–)2–4(–6) cm longis, (3–)4–7(–10) mm latis; foliis caulinis integris, anguste spathulatis, cuneatis; sepalis viridis vel argenteis, pubescentibus, oblongis, nonsaccatis, ca. 5 mm longis, ca. 1.8 mm latis; petalis spathulatis, aureis, 7–9 mm longis, 2.5–3 mm latis; pedicellis divaricatis, sigmoideis vel fere rectis, pubescentibus, 4–6 mm longis; siliquis erectis, compressis, ellipticis, 4–5 mm longis, ca. 3 mm latis; stylo 3–4 mm longo; loculis 2–4 ovulatis; seminibus immaturis exalatis; cotyledonibus accumbentibus.

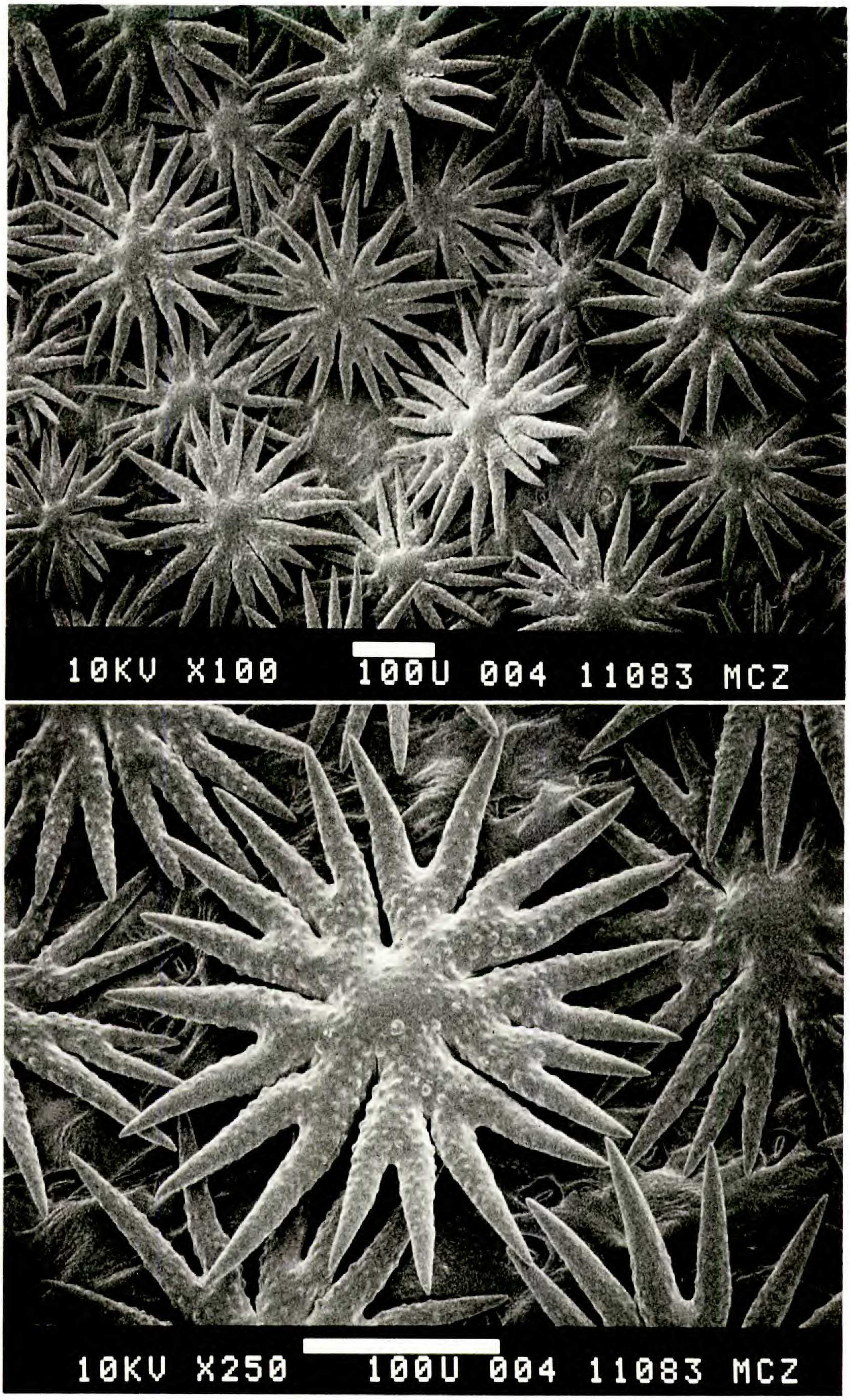

FIGURE 3. SEM photos of trichomes of **Lesquerella goodrichii** (*Goodrich 16951*): above, spacing of trichomes on leaf-surface; below, enlargement of single trichome.

TYPE. Utah, Millard Co., Desert Experimental Range, Tunnel Springs Mts., 21 mi SE of Garrison, T24S, R17W, S9, steep slopes and ridges, mostly N exposure, 8000 ft alt., 16 June 1982, *S. Goodrich 16951* (holotype, GH; isotypes, BRY, NY, UTC).

Perennial, densely covered throughout (except on petals and styles) with appressed radiate trichomes; caudex closely branched, branches usually covered with old leaf-bases; stems several to many, slender, simple, mostly decumbent, 8–14 cm long. Basal leaves numerous, erect, (1.5–)2–4(–6) cm by (3–)4–7(–10) mm; petiole to 3 cm long, slender; blade oblanceolate and entire to deltoid with broad tooth on each side. Sepals oblong, nonsaccate, ca. 5 by ca. 1.8 mm, greenish to silvery; petals erect, spatulate, not differentiated into blade and claw, 7–9 by 2.5–3 mm, yellow. Fruiting pedicels divaricately ascending to widely spreading, sigmoid to nearly straight, 4–6 mm long; siliques erect, elliptic, strongly compressed parallel to septum, 4–5 by ca. 3 mm, the valves densely pubescent on exterior, glabrous on interior, the septum entire, the replum elliptic, acute at apex, the style 3–4 mm long, slender, with expanded stigma, glabrous or with 1 or 2 trichomes near base; ovules 2 to 4 in each loculus, attached above middle of replum. Immature seeds wingless, often crowded and misshapen; cotyledons accumbent.

SPECIMENS EXAMINED. **Utah.** MILLARD CO.: Desert Experimental Range, 20 mi SE of Garrison, T24S, R17W, S3, 7200 ft alt., *Goodrich 16539* (BRY, GH); Canyon Mts., Lyman Canyon, 7.75 mi E of Oak City, T17S, R3W, S16, 8000 ft alt., *Goodrich 16883* (BRY, GH, NY, UTC), *Goodrich 17949* (BRY).

The strongly flattened siliques of *Lesquerella goodrichii* indicate a close relationship to *L. occidentalis* S. Watson, and these two species are indeed similar in many respects. However, the trichomes are decidedly different: in *L. occidentalis* they are stellate with radiating branches, have slender, elongated, very gradually tapering tips, and are free to their bases or nearly so; in *L. goodrichii* they have comparatively massive branches and branch bases, the tips contract abruptly to a point, and there is considerable fusion toward the center of each trichome. (See FIGURE 3. For comparison, see *plates 2* and *16* in Rollins & Banerjee, 1975—SEM pictures of trichomes of *L. occidentalis* subspp. *occidentalis* and *cinerascens*.)

Plants of *Lesquerella occidentalis* are more robust and have thicker stems and longer infructescences than those of *L. goodrichii*, which are usually delicate, with slender stems and narrow, short infructescences. The pedicels of *L. goodrichii* tend to be weakly sigmoid and erect or at least ascending, while those of *L. occidentalis* are strongly sigmoid and are more at right angles to the rachis or even descending. The long, slender petioles and relatively short blades of the numerous basal leaves of *L. goodrichii* are distinctive features of this species.

It is with some hesitation that I have cited the two collections from the Canyon Mountains under *Lesquerella goodrichii*. Although these plants have the same trichome type as those from the Desert Experimental Range, the leaf-blades are much broader and of a different shape, and they usually have two broad teeth instead of being entire. The two localities are at some distance from each other even though they are in the same county. Additional material with mature fruits is required from the Canyon Mountain area to see whether a minor taxon should be recognized under *L. goodrichii.*

Lesquerella parviflora Rollins, sp. nov.

Herba perennis multicaulis; caulibus procumbentibus vel adscendentibus, 1–3 dm longis; foliis radicalibus late obovatis, petiolatis, argenteis, sparse dentatis vel integris, 1–2 cm longis, 6–10 mm latis; foliis caulinis cuneatis, oblanceolatis vel oblongis, integris; sepalis oblongis, nonsaccatis, dense pubescentibus, 3–3.5 mm longis, ca. 1.5 mm latis; petalis spathulatis, flavis, 5–6 mm longis, 2–2.5 mm latis; pedicellis fructiferis recurvatis, 6–8(–12) mm longis; siliquis ellipticis vel prope globosis, dense pubescentibus, 3–4 mm longis, 2.5–3 mm latis; stylo glabro, ca. 3 mm longo; loculis 2-ovulatis; seminibus late oblongis vel prope orbicularibus, 2.5–3 mm longis, ca. 2.5 mm latis; cotyledonibus accumbentibus.

TYPE. Colorado, Rio Blanco Co., USGS Black Cabin Gulch Quadrangle, T3S, R100W, S13, ¾ mi S of spring in Tommy's Draw, 2595 m alt., 21 July 1982, *W. Baker & S. Sigstedt 82-308* (holotype, GH; isotype, CS).

Perennial, silvery from dense covering of stellate trichomes; stems several to numerous, prostrate to ascending, simple or rarely branched above, 1–3 dm long. Basal leaves tufted, petiolate, 1–2 cm by 6–10 mm; blade broadly obovate, rounded to obtuse, entire or with 1 or 2 broad teeth, silvery. Cauline leaves oblanceolate to nearly oblong, cuneate at base, entire. Sepals oblong, nonsaccate, 3–3.5 by ca. 1.5 mm, densely pubescent; petals erect, spatulate, scarcely differentiated into blade and claw, 5–6 by 2–2.5 mm, yellow; anthers nearly oval, ca. 1 mm long. Infructescences rather dense, ⅓–½ of stem length; fruiting pedicels recurved, 6–8(–12) mm long, densely pubescent; siliques mostly pendent, elliptic to nearly globose, usually slightly compressed parallel to septum, 3–4 by 2.5–3 mm or ca. 3 mm in diameter, densely pubescent on exterior, the valves glabrous or with few scattered trichomes on interior, the styles ca. 3 mm long, noncapitate, glabrous, the ovules 2 per locule, attached toward apex of replum, the septum entire, the replum nearly oval to obovoid in outline. Seeds oval to slightly longer than broad, somewhat compressed, wingless, 2.5–3 by ca. 2.5 mm; cotyledons broadly oblong to nearly orbicular, accumbent.

SPECIMENS EXAMINED. **Colorado.** RIO BLANCO CO.: USGS Segar Mountain Quadrangle, T1S, R96W, S1, 1 mi SSW of junction of Hay Gulch and White R., 1905 m alt., *Baker & Naumann 82-231* (CS, GH); USGS Philadelphia Creek Quadrangle, T1S, R100W, S21, 2.45 mi SSE of junction of West Fork Spring Creek and McDowell Gulch, 2316 m alt., *Kelley & Naumann 82-155* (CS, GH); Cathedral Bluff Rim Road, Piceance Basin, lat. 39°46′36″ N, long. 108°33′38″ W, *Peterson et al. 1141* (CS), *Painter et al. 132* (CS); USGS Jessup Gulch Quadrangle, T2S, R96W, S21, 2.2 mi NNE of junction of Collins Gulch and Piceance Creek, *Walker & Naumann 82-213* (CS); T3S, R100W, S24, NE ¼, 1.8 km NE of confluence of Lake Creek and Cathedral Creek, Parachute Creek Member of Green River Formation, *Wilken 13866* (COLO, CS, GH, RM).

The recurved pedicels of *Lesquerella parviflora* are similar to those of *L.*

arenosa (Richardson) Rydb. and *L. ludoviciana* (Nutt.) S. Watson, and the siliques of these three species are somewhat alike. The most fundamental differences between *L. parviflora* and the other two species are in ovule number and in the position of the funiculi on the replum of the silique. In *L. parviflora* there are only two ovules per locule and the two funiculi are restricted to an area near the apex of the replum; in both *L. arenosa* and *L. ludoviciana* the number of ovules is variable, ranging from four to eight in each locule, and the funiculi are arranged not only toward the apex of the replum but down the sides as well. Although the trichomes of all three species are stellate, with four to six primary rays (each of which is forked or bifurcate to provide anywhere from ten to twenty free tips), those of *L. parviflora* are smaller, with shorter, more massive, more tapered ultimate branches and a greater amount of fusion toward the center of the trichome than is found in the other two species. Characteristically, the trichomes are spreading on the siliques of *L. arenosa* and *L. ludoviciana,* while they are closely appressed in *L. parviflora.* There is a sharp difference in the shape of the basal leaves: in *L. arenosa* and *L. ludoviciana* the inner basal leaves are linear or nearly so with a scarcely differentiated petiole, but in *L. parviflora* all of the basal leaves are distinctly differentiated into a comparatively broad blade and a short petiole.

A significant feature of *Lesquerella parviflora* is the presence in the inflorescences of short shoots subtended by leafy bracts. This is particularly evident in *Wilken 13866,* where many of the specimens are in flower. The only other species of *Lesquerella* known to have short shoots in the inflorescences are *L. argyrea* (A. Gray) S. Watson subsp. *diffusa* (Rollins) Rollins & E. Shaw and *L. peninsularis* Wiggins, both of which occur exclusively in Mexico.

Among the specimens of the seven collections of *Lesquerella parviflora* cited, there is considerable diversity, which is probably attributable in part to the habitat. *Baker & Sigstedt 82-308* was collected on shale ledges, implying an exposed habitat. Quite compact in the caudex area, these specimens have prostrate stems, narrow, dense infructescences, and short pedicels. The siliques are uniformly elliptic in outline and slightly compressed parallel to the septum. The specimens of *Baker & Naumann 82-231,* collected "on shale with *Ribes aureum* and *Pinus,*" show both decumbent and upright stems, looser infructescences, slightly longer pedicels, and elliptic to subglobose siliques. *Kelley & Naumann 82-155,* "common on slopes of canyon with *Acer, Prunus, Betula,* and *Agropyron,*" is made up of sprangly specimens with ascending, sparsely branched stems, loose infructescences, long pedicels, and elliptic siliques that are noticeably compressed parallel to the septum. From my experience and observations in the field involving other species of *Lesquerella,* it appears that the differences in habit shown by these collections probably reflect responses to habitat: in the first instance, a dry, open, possibly windswept area; in the second, a somewhat more protected locale; and in the third, probably a shady situation with deep soil and other conditions favoring more rapid growth than normally takes place in the more open habitats. The variation in silique shape noted in *Baker & Naumann 82-231* is probably genetic and reflects the type of diversity found between (not within) populations in other species of *Lesquerella.* This diversity cannot be explained from the material available.

Polyctenium williamsiae Rollins, sp. nov.

Herba perennis, caespitosa; caudicibus ramosis; foliis pectinatis, sparsim pubescentibus; caulibus erectis vel decumbentibus, simplicibus, 4–10 cm longis; inflorescentiis corymbosis; petalis obovatis vel spathulatis, truncatis, 3–3.5 mm longis, 1.8–2 mm latis, albis vel purpureis; infructescentiis elongatis; pedicellis adscendentibus vel divaricatis, rectis, pubescentibus, 3–5 mm longis; siliquis late oblongis, glabris, 3–4 mm longis, 2–2.5 mm latis; stylo ca. 0.5 mm longo; seminibus immaturis, oblongis, immarginatis.

TYPE. Nevada, Washoe Co., Virginia Range, T17N, R20E, S16, foothills E of Little Washoe Lake, edge of a vernal pond, 5680 ft alt., *A. Tiehm 7135 & M. Williams* (holotype, GH; isotypes to be distributed).

Perennial with taproot and with occasional underground root branches bearing retoños along their length; caudex loosely branched. Basal leaves densely tufted, stiff, pectinate, pubescent with mostly dendritically branched trichomes, these interspersed with larger, simple or forked trichomes; linear leaf segments often tipped with large, simple or forked trichomes. Cauline leaves similar to basal, sessile, nonauriculate. Inflorescences densely corymbose; sepals broadly oblong, ca. 2 mm long, hyaline margined, greenish to purplish, sparsely pubescent; petals obovate to broadly spatulate, truncate at apex, gradually tapering to point of insertion, 3–3.5 by 1.8–2 mm, whitish to purplish; anthers nearly orbicular, less than 0.5 mm long. Infructescences elongated; pedicels ascending to divaricately ascending, straight, 3–5 mm long, sparsely pubescent; siliques crowded, divaricately ascending, broadly oblong to nearly oval in outline, rounded above and below, 3–4 by 2–2.5 mm, compressed (usually unevenly) in plane opposite to that of septum, mostly glabrous, the styles thick, ca. 0.5 mm long, the stigma slightly expanded beyond diameter of style, the ovules 15 to 20 per locule, the funiculi slender, ca. 0.5 mm long. Immature seeds broadly oblong, plump, wingless.

Greene (1912), in setting up *Polyctenium* E. Greene as a genus distinct from *Smelowskia*, believed that it consisted of three species, *P. bisulcatum* E. Greene, *P. fremontii* (S. Watson) E. Greene, and *P. glabellum* E. Greene. However, it was later shown (Rollins, 1938) that all of the material then available, including the types of Greene's species, was referable to a single species consisting of two varieties. The first incontrovertible evidence that *Polyctenium* is not monotypic comes from the newly described *P. williamsiae*. Comparison of this species with the only other known species in the genus, *P. fremontii*, yields several differences. The siliques of *P. williamsiae* are broadly oblong to nearly oval—much shorter and wider and thus of a very different shape than the linear, much longer, narrower siliques of *P. fremontii*. The flowers of *P. williamsiae* are considerably smaller than those of *P. fremontii*. The styles of *P. williamsiae* are about half the length of those of *P. fremontii*. The dried leaves, stems, and siliques are greenish in *P. williamsiae* and gray in *P. fremontii*. The valves of the siliques in *P. fremontii* are smooth and rigid, while those of *P. williamsiae* are uneven, showing depressed areas that indicate a lack of rigidity in the valve wall.

The generic status of *Polyctenium* has been considerably strengthened by the discovery of a second species. Although Jepson (1936) and Abrams (1944) did not accept *Polyctenium,* the genus has been recognized in the more recent floras (e.g., Munz, 1959; Hitchcock & Cronquist, 1973) that cover the area where it occurs.

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